Land Use/Land Cover Analysis:
Comparison with Parcel Data for Project ENVVEST Study Area

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Introduction

The is analysis was prepared in support of PSNS Project ENVVEST to compare the land and cover data derived from satellite imagery with land use and land cover derived from parcel data for the ENVVEST study area. Land use and land cover data is used for a wide variety of purposes, including municipal and regional planning, land management, and habitat research to name a few. Digital databases of land use, land cover, and associated datasets are widely available in GIS formats from the Internet. *Land use* is commonly defined as human operations on land that intend to obtain products and/or benefits from the land; whereas *land cover* is defined as vegetation or anthropogenic constructions on the earth's surface. Consequently, these maps and databases involve some interpretation and may take into account either or both land use and land cover. Land use and land cover databases are derived from numerous forms of remote sensing and aerial photography, and are available in varying spatial scales ranging from small parcels to state-wide coverages to world-wide images.

USGS Land Use and Land Cover Data

Land Use and Land Cover (LULC) is a set of data available in GIS format for most of the contiguous United States and for Hawaii. LULC data is available from the USGS based upon 1:100,000- and 1:250,000-scale USGS topographic quadrangles. It is obtained from interpretation of aerial photography from the 1970's and 1980's, as well as using secondary sources such as land use maps and surveys. The data is in Universal Transverse Mercator (UTM) projection, referenced to the North American Datum of 1983 (NAD83), and are available in GIRAS (Geographic Information Retrieval and Analysis System) and CTG (Composite Theme Grid) formats. Additionally, LULC data uses the Anderson 2 classification scheme for delineation of the different land uses and covers. All LULC data is free of charge and can be downloaded via FTP at http://edc.usgs.gov/geodata/. Layers including political units, hydrologic units, census county subdivisions, and Federal and State land ownership are also available.

Additionally, shapefiles that are compatible with ArcView can be downloaded free of charge at http://www.webgis.com/lulcdata.html.

The Anderson classification scheme for land use and land cover data was developed and introduced in 1976 via a US Geological Survey Professional Paper (Anderson, et. al, 1976). The classification scheme originally had 2 levels. Anderson 1 includes nine general levels of classification, while Anderson 2 contains 21 more specific classifications that further define and delineate the level 1 classifications. Higher levels of classification have also been developed up to level 5, although few go beyond a third level. Because the original focus for the Anderson classification system was habitat-resource based, as opposed to the current more standard usage of LULC data for management of anthropogenic land usage, the standard system is commonly altered to meet the needs of an individual project. In Table 1, the standard Anderson 2 classification scheme is shown, where the more general classes of level 1 are shown in bold. Additionally, an example of a level 3 classification scheme, developed by the Delaware Office of State Planning Coordination, can be found at http://www.pamagic.org/DataStds/Current/DataStandards_LandUse_05-22-02.pdf.

Table 1. Level 2 Anderson classification scheme for Land Use and Land Cover (LULC) data. The 9 classifications for level 1 are shown in bold. Taken from http://geo-nsdi.er.usgs.gov/metadata/other/epa/giras-lulc/sdd/metadata.faq.html.

Value	Definition
1	**Urban or built-up land**
11	Residential
12	Commercial and services
13	Industrial
14	Transportation, communication, utilities
15	Industrial and commercial complexes
16	Mixed urban or built-up land
17	Other urban or built-up land
2	**Agricultural land**
21	Cropland and pasture
22	Orchards, groves, vineyards, nurseries, and ornamental horticultural
23	Confined feeeding operations
24	Other agricultural land
3	**Rangeland**

31	Herbaceous rangeland
32	Shrub and brush rangeland
33	Mixed rangeland
4	**Forest land**
41	Deciduous forest land
42	Evergreen forest land
43	Mixed forest land
5	**Water**
51	Streams and canals
52	Lakes
53	Reservoirs
54	Bays and estuaries
6	**Wetland**
61	Forested wetland
62	Non-forested wetland
7	**Barren land**
71	Dry salt flats
72	Beaches
73	Sandy areas not beaches
74	Bare exposed rock
75	Strip mines, quarries, gravel pits
76	Transitional areas
8	**Tundra**
81	Shrub and brush tundra
82	Herbaceous tundra
83	Bare ground
84	Wet tundra
85	Mixed tundra

9	Perennial snow or ice
91	Perennial snowfields
92	Glaciers

National Land Cover Data

The National Land Cover Data (NLCD) is a set of GIS-accessible, single band raster images with a 21-class land cover classification scheme for the United States. The data has a 30-meter spatial resolution and is derived Landsat Thematic Mapper (TM) satellite data from the early to mid 1990's (circa 1992). Analysis of the TM data was conducted using large-scale mosaics with aerial photography as a secondary "ground-truthing" source. NLCD is set to the Alberson conic Equal Area projection and is referenced to NAD83. Files for all states are available free of charge as downloadable (FTP) 8-bit binary files and as Geo-TIFF files for most states at http://edcwww.cr.usgs.gov/pub/data/landcover/states/ with information on the data at http://landcover.usgs.gov/natllandcover.html. A new enhanced version is slated for 2005 using Landsat data from 2000. In addition, NLCD can be downloaded from the USGS seamless server at http://seamless.usgs.gov.

The classification scheme for NLCD differs from the Anderson 2 classification scheme and is sometimes called a "modified Anderson 2 classification scheme." Some classifications have been combined, whereas others are indistinguishable using TM imagery and have been eliminated from the classification scheme. A list of the classifications is given in Table 2, and a more comprehensive explanation can be found at http://landcover.usgs.gov/classes.html.

Table 2. The 21-class classification scheme for the National Land Cover Data (NLCD).

	Water
11	Open Water
12	Perennial Ice/Snow
	Developed
21	Low Intensity Residential
22	High Intensity Residential
23	Commercial/Industrial/Transportation
	Barren
31	Bare Rock/Sand/Clay
32	Quarries/Strip Mines/Gravel Pits
33	Transitional
	Vegetated; Natural Forested Upland
41	Deciduous Forest
42	Evergreen Forest
43	Mixed Forest
	Shrubland
51	Shrubland
	Non-natural Woody

61	Orchards/Vineyards/Other
	Herbaceous Upland
71	Grasslands/Herbaceous
	Herbaceous Planted Cultivated
81	Pasture/Hay
82	Row Crops
83	Small Grains
84	Fallow
85	Urban/Recreational Grasses
	Wetlands
91	Woody Wetlands
92	Emergent Herbaceous Wetlands

A plethora of other sources of land use and/or land cover data is also available from the Internet with various resolutions and spatial scales. The Multi-Resolution Land Characteristic Consortium has links to various website and can be found at http://www.epa.gov/mrlc/data.html. It has links to the National Land Cover Data (NLCD), the GAP analysis project, the North American Landscape Characterization (NALC), the Global Land Cover Characterization (GLCC), and many others. Links and information about land cover reference data sets is also given by the EPA at http://www.epa.gov/owowwtr1/watershed/landcover/lulcusa.html. Additionally, a website by NASA lists many different types of research activities and remote sensing techniques used for analysis of land use and land cover. This website can be found at http://www.earth.nasa.gov/research/land/index.html.

Explanation of Analysis of Land Use and Land Cover for the ENVVEST Study Area Based on Parcel Data

GIS Analysis
1) The attribute table from the POLY.shp file obtained from Vickie Whitney was joined with the LANDCODE.dbf file based on the common field, SAPN/APN. This allowed the shapefile attribute table to list the parcel number and the land use for every parcel.
2) The watersheds.shp file was obtained from Heather Halkola. Within the geoprocessing wizard, the "clip" feature was used to clip the watershed area from the POLY.shp file. (Sort of a cookie-cutter clip of just the study area)
3) The "union" feature within the geoprocessing wizard was used to union the Watershed.shp and the clipped POLY file. This allowed the attribute table for the new layer to contain the parcel number (APN), land use, and the sub-watershed in which it is contained for all parcels. The final shapefile is called **Parcels_landuse.shp**.
4) Within the attribute table of the new shapefile, an additional column was created called Area_ to calculate the new areas of each parcel. This step was necessary because some of the parcels were split during the clip, but the areas were not updated to reflect this change. The areas were calculated using the advanced field calculator. The VB code used was to type dblArea in the bottom box, while typing in the top box:

```
Dim dblArea as double
Dim pArea as IArea
Set pArea = [shape]
Dbl Area = pArea.area
```

Excel Analysis
1) The database file was then imported into Excel. All unnecessary columns were removed, and the new file contained only the APN number, CH3D number, land use, landcode, and the newly calculated area. (The original land use data contained two columns of land uses, one which contained most of the data and one that contained only "Right of Way," "Lake," and "Unknown" categories. Because these parcels were not labeled in the primary land use column, these categories were moved over to fill the gaps. Any remaining cells without land use data were given the title of No Label.)
2) This file was saved as a comma-separated file (.csv) for import into Matlab.

Appendix C2

Matlab Analysis
1) The comma-separated file was imported into Matlab, and the data was summarized based on the CH3D number and the land use (i.e. the areas for all parcels in a given watershed with a certain land use were summed).
2) Percent impervious values for each type of land use were originally obtained from the file "full county landcodes vs. imperviousness1.xls" from David Nash (Kitsap County). The file was rearranged slightly by Chris May, and this was the final configuration used in the analysis.
3) Percent impervious values for each watershed were calculated based on using all 42 specific categories and also using the 8 general categories outlined in the "May_Parcel_LULC_CodeKey.xls" file (which aggregate the 42 specific land use categories into 8 more general classifications). This is also shown in Table 1 (below).
4) The final summary of all data is contained in "ImperviousSummary.xls," and I have all the Matlab code if anyone would every want to use it. The Excel file is split into several worksheets. The worksheets that begin with "Gen_" are summaries of the data collected using the 8 general categories, whereas those beginning with "All_" use the 42 categories. The worksheets ending with "_LongVersion" show every individual land use for each watershed, whereas those ending in "_CondensedVersion" show the total % of impervious area for the entire watershed. A comparison between both of these classifications is also shown in the "Comparison" worksheet.

	% Impervious
Undeveloped	**3.96%**
vacant	6.20%
open_land	3.62%
wooded	2.58%
TaxTitle	7.20%
Low Density Residential	**13.46%**
rural	8.04%
estate	9.84%
suburban	13.04%
urban_low	21.79%
Medium Density Residential	**39.24%**
urban_medium	45.09%
urban_standard	38.47%
mobile_park	40.49%
High Density Residential	**58.79%**
urban_high	58.79%
Commercial/Industrial	**46.97%**
commercial_retail	61.18%
commercial_service	46.90%
industrial_light	28.59%
industrial_heavy	46.53%

parking	44.94%
streets_hiways	27.28%
industrial_general	53.48%
hotel_motel	59.51%
hospital	46.80%
docks	40.11%
church	40.33%
transportation	33.42%
Transportation	**41.23%**
auto_hiway	56.72%
RightofWay	41.55%
rail	15.97%
Parks, Etc.	**8.17%**
parks	7.73%
parks_special	38.78%
parks_resort	7.24%
Public Facilities, Utilities	**17.60%**
utilities_general	32.09%
facilities	18.00%
airports	15.20%
cemetery	10.17%
schools	29.63%
Unknowns (+ NoLabel)	10.92%
water	6.60%
gas	26.95%
mines	25.67%
Electric Power	8.07%
phone_tv_radio	1.39%

Table 1. The 8 general categories are shown in red, and the 42 more specific categories are shown in black.

Attachment 1: Spreadsheet file with calculations of Total Impervious Area (TIA) by watershed using both classification schemes:

ImperviousSummary2.xls